

polarizer layer before the coating step. A thin film metal oxide layer may be applied to the first hardcoat layer before the coating step.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] Other objects, features and advantages will occur to those skilled in the art from the following description of a preferred embodiment and the accompanying drawings, in which:

[0022] **FIG. 1** is a cross-sectional view of a prior art topsheet with polarizer;

[0023] **FIG. 2** is a cross-sectional view of a topsheet with a polarizer according to the present invention;

[0024] **FIG. 3** is a cross-sectional view of a touch screen with a topsheet with a polarizer, combined with an LCD, according to the present invention;

[0025] **FIG. 4** is a cross-sectional view of a topsheet with a polarizer and a thin metal oxide film, according to the present invention; and

[0026] **FIG. 5** is a flow diagram of a method of manufacturing a topsheet with a polarizer layer according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0027] The present invention features a polarizer topsheet as shown in **FIG. 2** which overcomes the technology problems found in prior art. The polarizer topsheet in **FIG. 2** has a PET or polycarbonate support layer **70** laminated above the polarizer **72**. The thickness of the PET or polycarbonate support layer is between 0.001 and 0.010 inches. This construction with the support layer above the polarizer protects the polarizer material from damage caused by the crushing pressure on the topsheet resulting from finger or stylus contact. It also reduces the potential for damage due to flexing of the topsheet as it is pressed by a finger or stylus, by reducing the radius of flex of the polarizer material.

[0028] A hardcoat **74** may be coated on the top surface of the topsheet. This protects the topsheet from scratches. Hardcoat is typically a cured acrylic resin, coated onto the surface of a substrate by applying a liquid acrylic material, then evaporating away the solvents in the liquid, then curing the acrylic with UV light. The acrylic may also contain silica particles. These transparent particles give a roughened finish to the cured hardcoat, giving it anti-glare optical properties. Hardcoat materials and coating services such as the Terrapin product from Tekra Advanced Technologies Group in Berlin, Wisconsin have proven suitable for the purposes described herein.

[0029] A hardcoat **76** may also be coated on the bottom surface of the topsheet, between the polarizer **72** and the conductive coating **78**. This hardcoat protects the polarizer and reduces the dehydration and other effects of vacuum and heat on the polarizer during the conductive coating process. In addition, an anti-glare hardcoat under the conductive coating has the effect of diffusing light that is reflected from the adjacent conductive coating layer, reducing glare and also reducing Newton rings which otherwise form due to the proximity of two reflective conductive coating layers separated by an air gap and spacer dots. The hardcoat between

the polarizer and the conductive coating also protects the polarizer from physical damage when pressure is put onto the topsheet by finger touch or stylus. Such pressure causes flexing of the topsheet and also can cause damage where the touch screen spacer dots are pressed against the topsheet causing local, severe deformation of the topsheet. The relatively high durometer of the acrylic and silica hardcoat relative to the polarizer material reduces local stresses on the polarizer material under touch or stylus pressure.

[0030] The conductive coating described herein is typically ITO (indium tin oxide) with a conductivity between 100 ohms per square and 2000 ohms per square. For higher resistance in the range of 1000 to 4000 ohms per square, tin antimony oxide is sometimes used. These coatings are typically applied onto sheets of organic materials such as PET, using a vacuum sputtering process. The vacuum sputtering process may include plasma etching of the support layer, followed by sputtering of one or more coats of metal oxides. For touch screen use, the last layer to be deposited is a conductive layer, so the surface is conductive. Thin film layers of silicon dioxide and/or titanium oxides may be used in combination with the conductive layer in suitable thicknesses to form an anti-reflective stack. Typical thickness of each layer for this purpose is $\frac{1}{4}$ wave of visible light. The lower layers of metal oxides may also be selected to serve the purpose of enhancing adhesion of the conductive metal oxide layer. Deposition of such layers of thin film metal oxides is done by Neovac of Santa Rosa, Calif. and others.

[0031] A resistive film type touch screen **10** with a topsheet **8** including a polarizer layer **6** combined with an LCD **12** is shown in **FIG. 3**. Touch screen **10** includes substrate **4**, typically glass, coated with a transparent conductor **1**, typically Indium Tin Oxide (ITO). The ITO is typically applied in a vacuum sputtering process which may also include additional layers of sputtered materials such as silicon dioxide (SiO_2) adjacent to the ITO **1**. Topsheet **8** is separated from substrate **4** by spacer dots **2**. Topsheet **8** includes a layer of plastic **3**, typically PET, polarizer layer **6**, and ITO layer **5**.

[0032] The LCD **12** comprises a layer of liquid crystal material **14** sandwiched between 2 substrates **16**, **18**, typically made of glass. Layers of ITO **20**, **22** are deposited on each substrate adjacent to the liquid crystal material. Electrical signals are selectively applied to specified areas of the liquid crystal material via signal lines patterned in the ITO. Polarizer **26** is laminated onto glass substrate **18**. With polarizer layer **6** in topsheet **8**, there is no need for a polarizer layer on glass substrate **16**, as would be typical of an LCD without topsheet **8** according to the present invention.

[0033] All materials between the two polarizers of an LCD must be optically isotropic. An LCD functions by orienting light into certain polarities, and any material which diffuses, refracts, or changes polarity of light will reduce the performance of the LCD. Glass and some polycarbonates are optically isotropic. PET is not. Thus, the construction of a polarizer topsheet must use all isotropic materials below the polarizer layer. Materials meeting this requirement include some polycarbonates and cellulose triacetate (CTA). By placing polarizer layer **6** below support layer **3**, it is possible to use non-optically isotropic PET for layer **3**.

[0034] There are several types of polarizing materials, including reflective polarizers, dichroic polarizers, and